

The use of ultrasonography in traumatic muscle lesions: A practical first-line imaging tool

Ultrasonography in traumatic muscle lesions

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Abstract

Aim: In this study, we aimed to evaluate traumatic muscle lesions and trauma-related gross intramuscular hemorrhages using ultrasonography (US).

Material and Methods: This retrospective study included 32 cases (23 males, 9 females) with a history of muscle trauma that underwent US. The mean age was 24.3 years. Static and dynamic US and color Doppler US were performed in axial and longitudinal planes. Patients were divided into two groups as penetrating and non-penetrating (blunt) muscle trauma. The absence of intramuscular hematoma/fluid and muscle fibers was accepted as the criteria of muscle rupture in both trauma types. Non-penetrating traumas were also divided into intrinsic and extrinsic. Intrinsic muscle injuries were graded as mild, moderate, and severe. **Results:** Among the cases, 78.1% (n=25/32) developed as a result of non-penetrating trauma and 21.9% (n=7/32) cases as a result of penetrating trauma. Approximately 2/3 (64%) of non-penetrating muscle traumas (n=25/32) were intrinsic and 1/3 (36%) were extrinsic. In all cases, including unilateral muscle lesions such as collection/mass appearances compatible with hemorrhage-hematoma of various sizes and ages were demonstrated in gluteus maximus (25%), quadriceps femoris (18.7%), sternocleidomastoid (18.7%), rectus abdominis (15.6%), hamstring (9.4%), biceps brachii (6.3%) and gastrocnemius (6.3%). No vascularization in hemorrhage-hematoma was detected with Doppler US in any patient. Discontinuity in traumatized muscle fibers was present in all cases. Intrinsic muscle injury was classified as mild-grade 1 (12.5%), moderate-grade 2 (75%), and severe-grade 3 (12.5%) under ultrasonography.

Discussion: Ultrasonography is a practical and effective imaging method in the diagnosis of traumatic muscle lesions.

Keywords

Ultrasonography; Muscles; Injuries

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Introduction

The majority of radiologically detectable muscle pathologies are of traumatic origin. Ultrasonography (US) is a practical radiology method which enables rapid diagnosis of muscle traumas causing anatomical changes (muscle rupture, etc.) or resulting in collection (hematoma, etc.), does not contain ionizing radiation, is relatively inexpensive and portable when required, has a high anatomical resolution and also offers the opportunity for dynamic examination [1–4]. Connell et al. [5] reported that US was as useful as magnetic resonance imaging (MRI) in revealing acute hamstring injuries. However, in order to estimate the limits of US, it should be noted that US cannot show microscopic lesions such as micro-ruptures, which can cause muscle pain, and it has technical limitations. In this study, we aimed to evaluate traumatic muscle lesions developing in various forms and gross intramuscular hematomas due to trauma at different ages by using US.

Material and Methods

Thirty-two (23 males, 9 females) of 41 cases who were admitted with a history of various forms of muscle trauma and underwent US imaging between the years of 2001–2002 and 2011–2018, were included in this retrospective study. The mean age of the included patients was 24.3 years (range, 20 days–72 years). Nine cases were excluded from the study due to incomplete clinical data. The cases underwent static and dynamic gray-scale US in the axial and longitudinal planes with 7.5–8.0 MHz linear and 3.5–3.7 MHz convex probes and color Doppler US (CDUS) to evaluate vascularization. US examinations were performed in comparison with the contralateral side without any pathology. The mean time from trauma to US examination was 5.8 days (range, 5 hours–100 days). The cases were divided into two main groups as penetrating and non-penetrating/blunt muscle trauma in terms of causes of occurrence. Intramuscular hematoma/fluid and discontinuous muscle fibers were accepted as the criteria for muscle rupture in both types of trauma [6]. Non-penetrating traumas were also divided into two subgroups as intrinsic (caused by indirect muscle contraction by itself without any external impact) and extrinsic (caused by an external blunt impact) according to the mechanism of occurrence [7]. Intrinsic muscle traumas (ruptures, injuries) were graded as mild, moderate and severe based on the US appearances of the muscle in the axial plane. While there should be signs of injury (increased echogenicity, cavities less than 10 mm) in less than 5% of the muscle in mild muscle injury (grade 1, first-degree injury, elongation injury), it was examined whether there were partial ruptures involving more than 5% of the muscle but not 100% in moderate muscle injury (grade 2, second-degree injury, partial rupture). The muscle was completely ruptured from the myotendinous junction in severe muscle injury (grade 3, third-degree injury, complete rupture) [6]. Due to trauma, 13 cases were additionally evaluated using direct radiography, 15 with computed tomography (CT), and 18 with elective MRI after US. There was a history of hemophilia A disease in one case, hemophilia B disease in one case, and antiaggregant drug use in three cases as predisposing factors. The study was conducted in accordance with the ethical standards and the principles of the WHO Helsinki Declaration, after obtaining informed consent

from the patients or their relatives.

Results

The cases developed as a result of non-penetrating trauma accounted for 78.1% ($n = 25/32$), while 21.9% ($n = 7/32$) of the cases developed as a result of penetrating trauma. Among muscle injuries ($n = 25/32$) as a result of non-penetrating trauma, approximately 2/3 ($n = 16/25$, 64%) were of intrinsic (indirect) type, while approximately 1/3 ($n = 9/25$, 36%) were of extrinsic (direct) type. Collection/mass appearances, unilateral in all cases, compatible with hemorrhage-hematoma, in various sizes and ages, with the largest one measuring 30 x 7 x 5 cm and the smallest one measuring 3.0 x 1.5 x 1.3 cm, were observed in the gluteus maximus muscle (Figure 1) in 25% ($n = 8/32$), quadriceps femoris muscle (Figure 2) in 18.7% ($n = 6/32$), sternocleidomastoid muscle in 18.7% ($n = 6/32$), rectus abdominis muscle (Figure 3) in 15.6% ($n = 5/32$), hamstring muscle in 9.4% ($n = 3/32$), biceps brachii muscle in 6.3% ($n = 2/32$) and gastrocnemius muscle in 6.3% ($n = 2/32$) of the cases. CDUS revealed no vascularized hemorrhage-hematoma in any of the cases, but increased vascularization compatible with inflammation was observed in vital tissues adjacent to the hemorrhage-hematoma. Discontinuity was observed in traumatized muscle fibers in all cases ($n = 32/32$, 100%). Ultrasonographically, 12.5% ($n = 2/16$) of intrinsic muscle injuries were graded as mild (first-degree), 75% ($n = 12/16$) as moderate (second-degree), and 12.5% ($n = 2/16$) as severe (third-degree).

Discussion

Traumatic muscle lesions can develop in various forms. Depending on the type of trauma, penetrating and non-penetrating muscle injuries may occur. As a result, muscle rupture and intramuscular hematoma may be observed, and myositis ossificans, myositis, abscess and complications such as compartment syndrome, rhabdomyolysis and muscle hernia may develop in the post-traumatic period [4]. In our study, the lesions occurred as a result of non-penetrating trauma in the majority of cases (78.1%), and US could successfully show the lesions in both types of trauma.

Non-penetrating muscle rupture can develop by compression (extrinsically by direct trauma) or by distraction (intrinsically by indirect trauma) [7]. Compression-related muscle ruptures are common in contact sports and traffic accidents. In these cases, the muscle is compressed and crushed against the underlying bone by external factors. Therefore, muscle rupture and hematoma develop [4]. Prominent muscle ruptures developed due to compression are observed as irregular, subtle and low-echo cavities on US. The echogenicity of hematoma is generally high in the acute period, and the collection echo begins to decrease after approximately 2–3 days, and its margins can be understood more clearly [4,7]. In our study, 36% of non-penetrating muscle injuries occurred extrinsically due to compressive trauma and both acute and chronic lesions could be effectively demonstrated on US in accordance with the literature. In follow-up US examinations, the lesion begins to be filled with echogenic tissue from the periphery during the recovery period. Scar tissue is hyperechogenic, and an

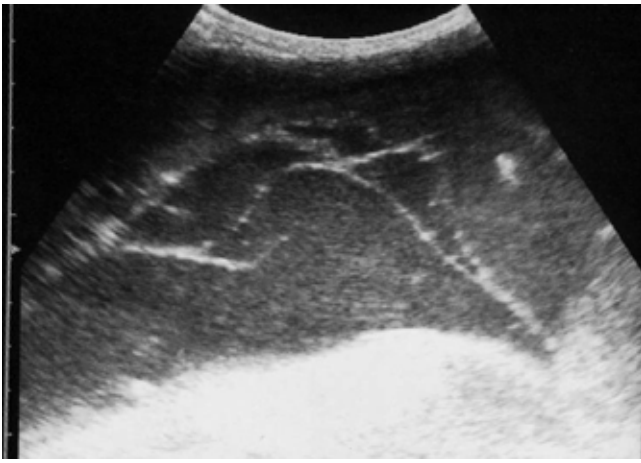


Figure 1. The US examination performed with a 3.7 MHz convex probe for the left gluteal region in a 38-year-old male patient, who had a non-penetrating / blunt trauma as a result of a car crash on his left hip one month ago, revealed a complicated fluid collection of 18x10 cm in the gluteus maximus muscle, with septum compatible with chronic hematoma and containing mobile echogenicities compatible with dense content (direct, compressive muscle rupture).

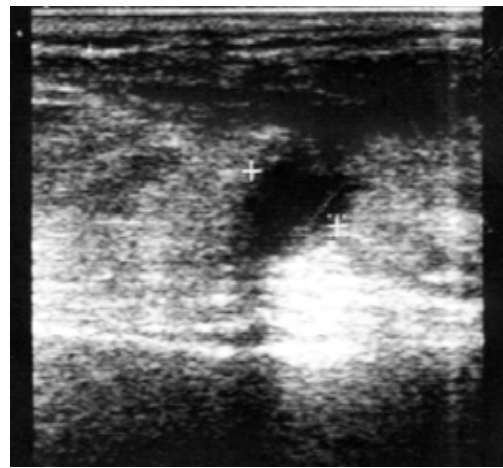


Figure 2b. The US examination of the patient with a 7.5 MHz linear probe revealed discontinuity in the muscle fibers distal to the right quadriceps femoris (myotendinous junction), compatible with complete muscle rupture (between + signs), anechoic fluid between discontinued parts (compatible with acute hemorrhage) and increased echogenicity in the muscle sections adjacent to this area.

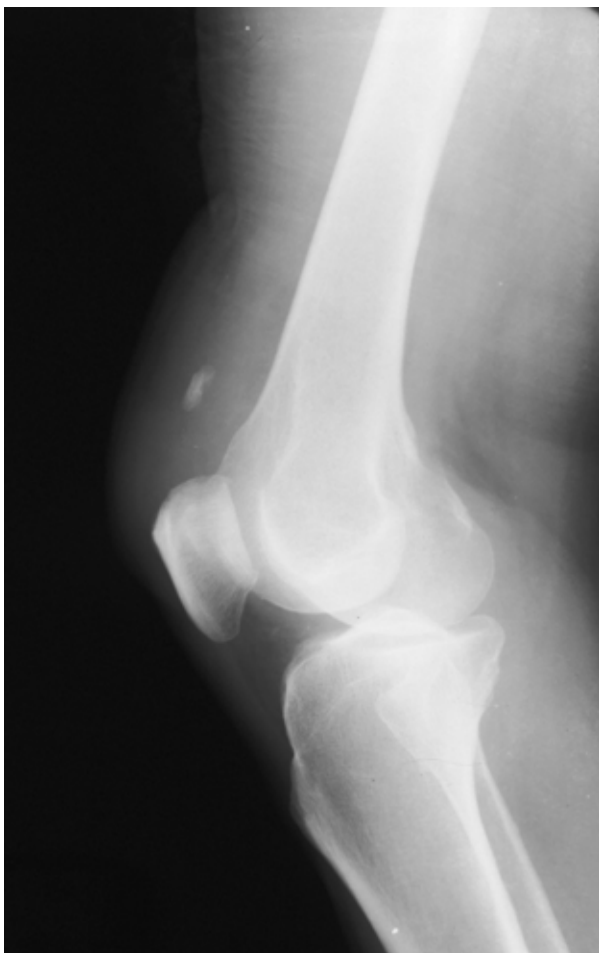


Figure 2a. In the lateral right knee radiograph of a 70-year-old male patient who had extrinsic, blunt knee trauma as a result of falling down five hours ago, the soft tissue swelling superior to the patella and soft tissue depletion and collapse distal to the quadriceps femoris muscle suggested quadriceps femoris rupture (retraction of the ruptured muscle). Bone fragments observed in this region were compatible with avulsed complete muscle rupture.

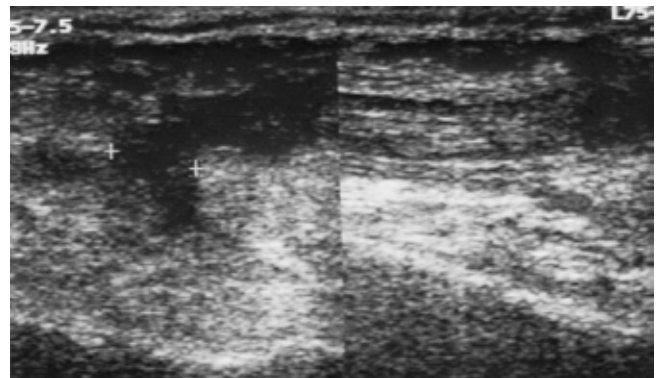


Figure 2c. In the comparative US examination of the distal and tendon of the right quadriceps femoris muscle (myotendinous junction) with the contralateral side in the sagittal plane, loss of integrity, complete rupture and anechoic fluid appearance could be clearly selected at the relevant localization on the right side (between + signs).

acoustic shadow can be observed if myositis ossificans develops. Myositis ossificans develops in nearly 20% of severe compressive ruptures [8]. Since our study was retrospectively designed, and follow-up US examinations of our cases could not be performed, the developmental process of scar tissue could not be monitored.

Unlike compressive ruptures, intrinsic muscle ruptures due to indirect trauma by distraction occur as a result of sudden and strong contractions or passive extension caused by the muscle itself. These ruptures are most frequently observed in the lower extremities, especially in the muscles crossing the joint. The most affected muscles are the hamstring muscles, rectus femoris muscles and medial gastrocnemius muscles [9-11]. The ruptured muscle is filled with blood in the acute period. Although there is no available classification for compressive ruptures, 3 main groups have been identified in this type of intrinsic, distractive ruptures based on sonographic findings as follows:

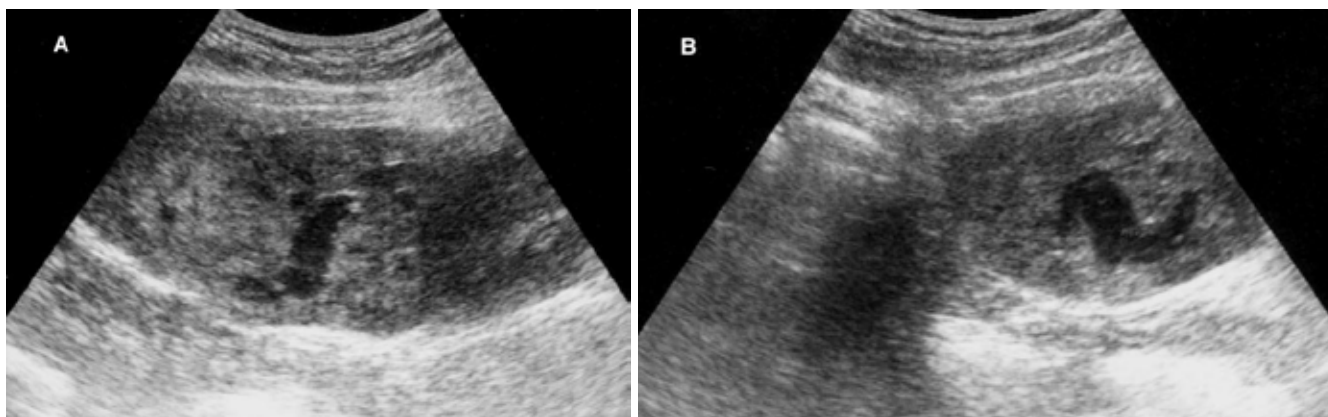


Figure 3a (sagittal) - 3b (transverse). The US examination performed with a 3.7 MHz convex probe in the first 48 hours of the left-sided swelling in the anterior wall of the abdomen after a severe cough attack in a 42-year-old male patient with hemophilia B revealed a posteriorly weighted acute hematoma (rectus sheath hematoma) of 30 x 7 x 5 cm in the rectus abdominis muscle, with unilateral echogenic mass appearance and partly anechoic areas. The anterior rectus abdominis muscle fibers were selected to be intact. The findings were evaluated as intrinsic muscle injury and were compatible with second-degree (partial) muscle rupture. Unlike intra-abdominal structures, the hematoma mass did not show movement by respiration since it belongs to the anterior abdominal wall.

elongation injury (first-degree, mild), partial rupture (second-degree, moderate) and complete rupture (third-degree, severe) [6]. On US, the muscle may appear mildly hyperechogenic due to edema. Even small hyperechogenic areas may be observed due to extravasated blood [12]. US reveals discontinuity in the muscle fibers and a hypoechoic gap in the muscle mass in cases of partial and complete muscle ruptures among indirect muscle ruptures that lead to more serious clinical consequences, and this gap is filled with hematoma. The free ends of the ruptured muscle fragments can be observed in the fluid [4]. In our study, these findings were successfully demonstrated in partial and complete muscle ruptures. US findings could be demonstrated less prominently and in a smaller area of the affected muscle in two cases diagnosed with a mild (first-degree) muscle injury. US examination should be performed in different planes in order to evaluate the amount of muscle remaining intact. If more than 2/3 of the muscle is ruptured, it may be indicative of surgical repair. It is also necessary to obtain images in the transverse plane for the determination of this condition [8,12]. Hematoma formation is the most prominent feature of muscle rupture. The size of hematoma usually indicates the extent of the underlying damage. However, intramuscular hematoma may be disproportionately large with the damage in patients with hemophilia or those receiving anticoagulant therapy [8]. In our study, one case with hemophilia B developed an acute hematoma of giant size in the rectus abdominis muscle due to second-degree (partial) muscle rupture only after severe cough (Figure 4). In another case with oral anticoagulant use and the anamnesis of vigorous efforts, a fluid collection (chronic hematoma) of 6 x 2.5 cm was observed in the biceps brachii muscle due to second-degree (partial) muscle rupture (Figure 5). Patients receiving anticoagulants may have spontaneous hemorrhages. However, soft tissue sarcomas, especially malignant fibrous histiocytoma, may emerge with acute intratumoral hemorrhage. A biopsy may, therefore, be required for an elderly person with a thigh hematoma not resorbing in the normal period [8].

Foreign bodies such as metal, glass, and wood can enter the muscle in penetrating muscle trauma. Thus, direct radiographs should be obtained first, and then reverberation, comet-tail artifacts, or posterior acoustic shadows should be sought by US. Although foreign bodies are generally hyperechogenic, a hypoechoic halo can be observed around the foreign body due to granulomatous reaction in chronic cases [13,14]. In addition to US, direct radiographs were obtained for trauma regions in all of the penetrating traumas, and CT examination was performed in some of them in order to investigate the presence of any foreign body in the wound in our study. No foreign body was revealed on US, direct radiography and CT. Muscle traumas should also be investigated for possible vascular damage, thrombosis, arteriovenous fistula, and pseudoaneurysm by CDUS [12]. In our study, CDUS was performed in all cases, and vascular lesions could be excluded in this way.

At the infraumbilical level, below the arcuate line, the rectus abdominis muscle lacks a posterior sheath. Peritoneal irritation may develop, and an acute abdomen may occur in some rectus abdominis hematomas. Therefore, it is necessary to make a definitive diagnosis. Ultrasonography can be useful to make a practical diagnosis in such cases. Berna et al. [15] reported that 11 of 13 hematoma cases were diagnosed by US, and the correct diagnosis was achieved in all 13 cases by CT in a series of 13 cases with rectus sheath hematoma. Moreno Gallego et al. [16] stated that when abdominal rectus sheath hematoma was correctly diagnosed, unnecessary surgical procedures would be decreased in most cases, and US was useful in diagnosis, but CT provided more accurate results compared to US. Berna et al. [17] performed US and CT examinations in all cases, and they were able to make a definitive diagnoses of hematoma in 9 cases using US and all cases using CT, in a series of 12 cases with abdominal rectus sheath hematoma and receiving anticoagulant therapy. In our study, all rectus abdominis ruptures and associated hematomas (n = 5/32) were diagnosed by US, and the effectiveness of US was confirmed by CT performed to investigate the presence of additional pathologies in all cases.

Dynamic imaging of the affected muscle by contracting during US can provide functional information [18]. In our study, it was possible to show and identify lesions in all cases thanks to a good evaluation of clinical data and obtaining good anamneses as well as proper US examination with dynamic imaging (co-use of linear-convex probes when needed, comparative examination of the lesioned muscle with the contralateral intact muscle and examination in different planes).

The most important limitation of our retrospective study is the limited number of cases undergoing US imaging and muscle types examined. Sending such cases to MRI instead of US due to some factors, such as the fact that MRI technology allows to complete the examination in a shorter period of time, and the number of these devices increases day by day, is among the most obvious reasons for this limitation. Another reason is thought to be sending cases with general body trauma directly to CT instead of US. A much larger number of patients could have enabled us to evaluate hemorrhage and rupture in different muscle groups and at different ages by US. The fact that we could not perform long-term follow-ups of muscle lesions with serial examinations can be considered as another limitation.

Conclusion

In conclusion, in case of proper evaluation of clinical data and anamnesis, US is a non-invasive, real-time, effective imaging method, which enables rapid and practical diagnosis of traumatic muscle lesions and accompanying gross intramuscular hematomas and the detection of the size and extent of the lesions, which does not contain ionizing radiation, and which provides multiplanar and dynamic imaging.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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